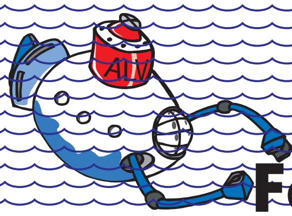

Feeling Crabby?

Focus
Deep-water crab populations in the Gulf of Alaska

Grade Level
5-6

Focus Question
Does water depth affect the reproductive biology of deep-water crabs?

Learning Objectives
Students will analyze data from a simulated sampling program to investigate the influence of water depth on size at reproductive maturity among deep-water crab populations.

Students will interpret results of their sampling program to draw conclusions about changes in size at reproductive maturity associated with water depth.

Students will apply their results to draw conclusions about appropriate fishery regulations to protect reproductive opportunity among deep-water crab populations.

Materials
❒ "Crab Squares" – make two copies of each of the four pages onto heavy paper (cover stock) and cut out the individual squares on a paper cutter

❒ Two shallow containers to hold the "Crab Squares," one labeled "200 m" and the other labeled "700 m"

Audio/Visual Materials
❒ (Optional) Pictures of deep-water crabs (download from http://oceanexplorer.noaa.gov)

Teaching Time
One to two 45-minute periods, depending upon the ease with which students manipulate numeric data

Seating Arrangement
Groups of two or three students

Maximum Number of Students
24

Key Words
Seamount
King crab
Overfishing
Reproductive maturity

Background Information
Seamounts (also called guyots) are undersea mountains that rise from the ocean floor, often with heights of 3,000 m (10,000 ft) or more. Compared to the surrounding ocean waters, seamounts have high biological productivity, and provide habitats for a variety of plant, animal, and microbial species. Numerous seamounts have been discovered in the Gulf of Alaska. Many of these seamounts occur in long chains that parallel the west coast of the U.S. and Canada. One of the longest chains, known as the Axial-Cobb-Eikelberg-Patton chain, is being intensively studied by the Ocean Exploration 2002 Gulf of Alaska Expedition.

During a 1999 expedition to the Patton Seamount, researchers discovered a large crab species previously unknown in Alaska as well as many other invertebrate species that are new to science. King crab species have been commercially important in Alaska for many years, but very little is known about the biology of their deep-water relatives. If deep water crabs become targets of commercial fishermen, what sort of regulations will be needed to protect the crab populations from overfishing? Will size restrictions that protect juvenile shallow-water crabs be effective for deep-water crabs as well? These questions are part of the focus of deep water crab exploration on the Gulf of Alaska Expedition.

Learning Procedure

This activity simulates a sampling program designed to study the effect of depth on growth and reproduction in a hypothetical deep-water crab population, based on an actual study of golden king crab, *Lithodes aequispina*, in the Bering Sea.

1. Explain that seamounts are the remains of underwater volcanoes, and that they are islands of productivity compared to the surrounding environment. Explain that because this productivity is concentrated in a relatively small area, seamounts are prime sites for commercial fisheries, and in Alaska one of the major fisheries is for king crab (which actually includes several crab species). The concentration of species in a relatively small area may also mean that fishery resources are particularly vulnerable to overfishing. Discuss the sort of biological information that would be important to fishery managers trying to establish appropriate fishing regulations for a new species. Students may identify a variety of information needs, but the list should include the minimum size at which the crabs are able to reproduce, since populations can be rapidly depleted if animals are harvested before reproduction can occur. Other answers might be size at maturity, age at maturity, percentage of females in the population, percentage of males in the population, and the distribution of length, weight, and size in a population. You may want to show pictures of deepwater crabs downloaded from the Gulf of Alaska Expedition website (see Resources).

2. Cut "Crab Squares" into individual pieces. Put "200 m" squares into a shallow container, and "700 m" squares into a separate container. Be sure the squares are well-mixed in each container.

3. Explain to the students that they will be collecting samples of deep-water crabs from two depths. Their objective is to estimate the minimum size at which the crabs are able to reproduce to determine whether fishery regulations that establish a minimum legal size should set different limits for crabs harvested at different depths. If you have more than four groups of students, have half of the groups draw 20 "Crab Squares" each from the "200 m" container, and the other half draw 20 "Crab Squares" from the "700 m" container. If you have four or fewer groups,

have each group draw 20 "Crab Squares" from both the "200 m" and "700 m" containers.

4. Have each group record their sampling results on the Data Sheets to show sample depth, size of individual male crabs, size of individual female crabs, size of individual female crabs with eggs, and size of individual male and female crabs found in mating pairs. Note that crabs with eggs will have their size recorded under "Female Crabs" and under "Female Crabs with Eggs." Similarly, mating female crabs will be listed under "Female Crabs" and under "Mating Female Crabs," and mating male crabs will be listed under "Male Crabs" and under "Mating Male Crabs."

5. Have groups pool their data for each depth, and calculate the mean size of male crabs, mean size of female crabs, mean size of female crabs with eggs, mean size of mating male crabs, and mean size of mating female crabs.

6. Display the summarized data on a blackboard, overhead projector, or flip chart. Lead a discussion of the significance of the results. Students' samples should show that the mean size of crabs from deeper water samples is less for both males and females, and that the average size of egg-bearing and mating crabs is also less for the samples from deeper water. The results suggest that a smaller minimum size would be needed to protect reproductive opportunity in deep-water crab populations than in shallow-water populations.

The BRIDGE Connection

www.vims.edu/bridge/biology.html

The "Me" Connection

Have students visit a local grocery store that sells seafood, and prepare a report on the origin of three species available in the store and what fishery management regulations are in place to ensure that these fishery populations are not overfished.

Connections to Other Subjects

English/Language Arts, Geography, Mathematics

Evaluation

Observe the students during Steps 4 and 5 of the learning procedure to ensure they are recording their data in an orderly manner, and are calculating summary statistics accurately. If individual evaluations are desired, have students write their interpretations of the data prior to the group discussion.

Extensions

Have students visit http://oceanexplorer.noaa.gov to keep up to date with the latest Gulf of Alaska Expedition discoveries.

Resources

http://oceanexplorer.noaa.gov – Follow the Gulf of Alaska Expedition daily as documentaries and discoveries are posted each day for your classroom use. A wealth of information can also be found at this site.

http://www.akmarine.org/whatishabitat.html – General information on fishery conservation issues in Alaska

http://www.sciencegems.com/earth2.html – Science education resources

http://www-sci.lib.uci.edu/HSG/Ref.html – References on just about everything

Somerton, D. A. and R. S. Otto, 1986. Distribution and reproductive biology of the golden king crab, *Lithodes aequispina*, in the eastern Bering Sea. Fish. Bull. 84:571-584. (The research paper on which this activity is based)

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments

Crab Square **collected at 200 m** **MALE** carapace length = **125 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **120 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **130 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **115 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **135 mm**
Crab Square **collected at 200 m** **MALE** carapace length = **125 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **120 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **130 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **115 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **135 mm**
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Crab Square **collected at 200 m** **MALE** carapace length = **125 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **115 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **135 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **100 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **150 mm**
Crab Square **collected at 200 m** **MATING PAIR!** **Male = 125 mm** **Female = 115 mm**	Crab Square **collected at 200 m** **MATING PAIR!** **Male = 120 mm** **Female = 110 mm**	Crab Square **collected at 200 m** **MATING PAIR!** **Male = 130 mm** **Female = 120 mm**	Crab Square **collected at 200 m** **MATING PAIR!** **Male = 115 mm** **Female = 105 mm**	Crab Square **collected at 200 m** **MATING PAIR!** **Male = 135 mm** **Female = 125 mm**
Crab Square **collected at 200 m** **MALE** carapace length = **95 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **155 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **135 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **115 mm**	Crab Square **collected at 200 m** **MALE** carapace length = **125 mm**

Crab Square collected at 200 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **110 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **120 mm**	Crab Square collected at 200 m **FEMALE** cara- pace length = **105** **mm**	Crab Square collected at 200 m **FEMALE** carapace length = **125 mm**
Crab Square collected at 200 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **110 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **120 mm**	Crab Square collected at 200 m **FEMALE** cara- pace length = **105** **mm**	Crab Square collected at 200 m **FEMALE** carapace length = **125 mm**
Crab Square collected at 200 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **110 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **120 mm**	Crab Square collected at 200 m **FEMALE** cara- pace length = **100** **mm**	Crab Square collected at 200 m **FEMALE** carapace length = **130 mm**
Crab Square collected at 200 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **110 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **120 mm**	Crab Square collected at 200 m **FEMALE** cara- pace length = **95** **mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **135 mm**
Crab Square collected at 200 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **105 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **125 mm**	Crab Square collected at 200 m **FEMALE** cara- pace length = **90** **mm**	Crab Square collected at 200 m **FEMALE** carapace length = **140 mm**
Crab Square collected at 200 m **MATING PAIR!** **Male = 125 mm** **Female = 115 mm**	Crab Square collected at 200 m **MATING PAIR!** **Male = 120 mm** **Female = 110 mm**	Crab Square collected at 200 m **MATING PAIR!** **Male = 130 mm** **Female = 120 mm**	Crab Square collected at 200 m **MATING PAIR!** **Male = 115 mm** **Female = 105 mm**	Crab Square collected at 200 m **MATING PAIR!** **Male = 135 mm** **Female = 125 mm**
Crab Square collected at 200 m **FEMALE** carapace length = **145 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 200 m **FEMALE** carapace length = **125 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **105 mm**	Crab Square collected at 200 m **FEMALE** **with eggs** carapace length = **115 mm**

Crab Square collected at 700 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **80 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **90 mm**	Crab Square collected at 700 m **FEMALE** cara- pace length = **75** **mm**	Crab Square collected at 700 m **FEMALE** carapace length = **95 mm**
Crab Square collected at 700 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **80 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **90 mm**	Crab Square collected at 700 m **FEMALE** cara- pace length = **75** **mm**	Crab Square collected at 700 m **FEMALE** carapace length = **95 mm**
Crab Square collected at 700 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **80 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **90 mm**	Crab Square collected at 700 m **FEMALE** cara- pace length = **70** **mm**	Crab Square collected at 700 m **FEMALE** carapace length = **100 mm**
Crab Square collected at 700 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **80 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **90 mm**	Crab Square collected at 700 m **FEMALE** cara- pace length = **65** **mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **105 mm**
Crab Square collected at 700 m **FEMALE** carapace length = **85 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **75 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **95 mm**	Crab Square collected at 700 m **FEMALE** cara- pace length = **60** **mm**	Crab Square collected at 700 m **FEMALE** carapace length = **110 mm**
Crab Square collected at 700 m **MATING PAIR!** **Male = 85 mm** **Female = 80 mm**	Crab Square collected at 700 m **MATING PAIR!** **Male = 80 mm** **Female = 90 mm**	Crab Square collected at 700 m **MATING PAIR!** **Male = 90 mm** **Female = 75 mm**	Crab Square collected at 700 m **MATING PAIR!** **Male = 75 mm** **Female = 95 mm**	Crab Square collected at 700 m **MATING PAIR!** **Male = 95 mm** **Female = 85 mm**
Crab Square collected at 700 m **FEMALE** carapace length = **115 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **55 mm**	Crab Square collected at 700 m **FEMALE** carapace length = **95 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **75 mm**	Crab Square collected at 700 m **FEMALE** **with eggs** carapace length = **85 mm**

Crab Square collected at 700 m MALE carapace length = 85 mm	Crab Square collected at 700 m MALE carapace length = 80 mm	Crab Square collected at 700 m MALE carapace length = 90 mm	Crab Square collected at 700 m MALE carapace length = 75 mm	Crab Square collected at 700 m MALE carapace length = 95 mm
Crab Square collected at 700 m MALE carapace length = 85 mm	Crab Square collected at 700 m MALE carapace length = 80 mm	Crab Square collected at 700 m MALE carapace length = 90 mm	Crab Square collected at 700 m MALE carapace length = 75 mm	Crab Square collected at 700 m MALE carapace length = 95 mm
Crab Square collected at 700 m MALE carapace length = 85 mm	Crab Square collected at 700 m MALE carapace length = 80 mm	Crab Square collected at 700 m MALE carapace length = 90 mm	Crab Square collected at 700 m MALE carapace length = 70 mm	Crab Square collected at 700 m MALE carapace length = 100 mm
Crab Square collected at 700 m MALE carapace length = 85 mm	Crab Square collected at 700 m MALE carapace length = 80 mm	Crab Square collected at 700 m MALE carapace length = 90 mm	Crab Square collected at 700 m MALE carapace length = 65 mm	Crab Square collected at 700 m MALE carapace length = 105 mm
Crab Square collected at 700 m MALE carapace length = 85 mm	Crab Square collected at 700 m MALE carapace length = 75 mm	Crab Square collected at 700 m MALE carapace length = 95 mm	Crab Square collected at 700 m MALE carapace length = 60 mm	Crab Square collected at 700 m MALE carapace length = 110 mm
Crab Square collected at 700 m MATING PAIR! Male = 85 mm Female = 80 mm	Crab Square collected at 700 m MATING PAIR! Male = 80 mm Female = 90 mm	Crab Square collected at 700 m MATING PAIR! Male = 90 mm Female = 75 mm	Crab Square collected at 700 m MATING PAIR! Male = 75 mm Female = 95 mm	Crab Square collected at 700 m MATING PAIR! Male = 95 mm Female = 85 mm
Crab Square collected at 700 m MALE carapace length = 55 mm	Crab Square collected at 700 m MALE carapace length = 115 mm	Crab Square collected at 700 m MALE carapace length = 95 mm	Crab Square collected at 700 m MALE carapace length = 75 mm	Crab Square collected at 700 m MALE carapace length = 85 mm